

The AT SPRINT 3A

A 4 band cw transceiver

Ultra small, ultra light, trail friendly rig.

Users manual



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Introduction:

The AT Sprint 3A is designed to provide the greatest amount of performance in the smallest and lightest package possible. The incentive to design and produce a rig of this type came from a desire to have a rig which was small enough, light enough and still be effective enough to be worth taking along on extended back packing trips. Because of the rigs light weight, it has become popular in the ARS monthly "Spartan Sprint", where the lightest rigs get the most points.

The new ATS-3A differs from the previous ATS-3 primarily by having an improved QSK T/R switching scheme which eliminates or greatly reduces problems of IMD from strong SWBC stations on the 40 and 30 meter bands.

Specifications:

General

- 80, 40, 30 and 20 meter operation
- Direct Digital Synthesizer VFO
- Push button operation
- Size: 3.2" long X 2.1" wide x 3/4 " tall
- Weight – 1.0 oz with one filter board installed
- 5.5 to 12 volt operating voltage, optimized for 9 volts.
- Receive current, 25 ma typical, no signal

Receiver

- Super-Heterodyne, single conversion, 4.9512 MHz IF
- 0.2 uv typical MSD
- Four crystal IF filter, excellent opposite side band rejection.
- Audio band pass filtering, peaked at 600 Hz
- 300 Hz band width. (@ -40 dB)
- Audio AGC
- 100 mw headphone driver amplifier

Transmitter

- Efficient FET RF power amplifier, up to 4 watts out with 12 volt supply, 2.5 watts output at 9 volts, 900 mW at 6 volts. Power output consistent on all bands.
- 500 ma typical Tx current at 9V, 2.5 watts out
- Spurious: -40 dBc max.

CW

- Iambic keyer, 10 to 40 wpm in 1 wpm steps, selectable A or B mode Iambic operation
- Auto straight key detect (on power up)
- 124 character Keyer message memory, with paddle controlled pause, stop and beacon mode.
- Up to three separate keyer messages possible
- 600 Hz side tone

Operation:

Band selection:

Disconnect power if the rig is on and plug the desired operating band module into the main board. Restore power and the rig will power up on one of the following QRP frequencies. (as determined by the installed band module)

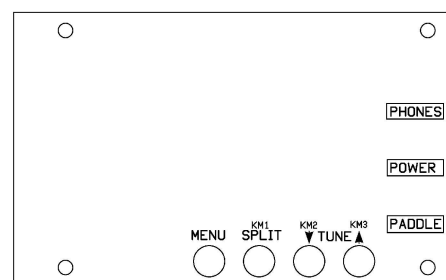
80M: 3.560 MHz **40M:** 7.030 MHz **30M:** 10.110 MHz **20M:** 14.060 MHz

Power on/off

Power is applied and removed by using the external power jack and plug. On power up, the side tone will indicate the band module currently installed by sending 80M, 40M, 30M or 20M.

Controls:

The rig is operated by using four push button switches, locations shown in diagram to right. These are best operated by “clicking” them side to side, rather than actually pushing down on them. Switches may have more than one function, depending on the option selected by the **“MENU”** switch.



Tune up / Tune down

The operating frequency is tuned in 50 Hz steps by clicking the **“Tune up”** or **“Tune down”** switches. A single click of the switch will tune in a single 50 Hz step. If the switch is held closed for longer than one (1) second, the frequency will automatically start to tune at about a 10 step per second rate, until the switch is released.

Band limits:

A double beep (“I”) will sound by the side tone at the upper and lower limits of the CW segment of the band in use. **THE RIG WILL NOT TUNE BEYOND THE CW BAND SEGMENT.**

SPLIT - RIT (Receive Incremental Tuning) and XIT (Transmitter Incremental Tuning)

RIT: Click and hold the **SPLIT** switch for about one (1) second until “R” is announced. RIT is now active. Tuning the rig will now change the receiver frequency, leaving the transmitter frequency set to where it was when RIT was enabled.

XIT: Click and hold the **SPLIT** switch for one (1) second past the announcement “R”, until the letter “X” is sent. XIT is now active and now the transmitter frequency changes with tuning and the receiver frequency stays fixed. Be careful when using XIT, as there is no way to check the new transmit frequency to see if it is being used by someone else, though this isn't too much of a concern if your using XIT during a DX pile up or chasing the QRP-L FOX.

When RIT or XIT mode is entered, the frequency readout is zeroed. In addition, 1 kHz marker “beep” will sound each time you move 1 kHz from the initial start frequency. A double beep will sound when you hit the original start frequency again. This makes it easy to “go up” or “go down” 1 or 2 kHz. When tuning below the start frequency, the AFA will read out “99--”, so you have to do a little mental arithmetic if you want to know exactly how far you've moved down in frequency.

Exiting RIT/XIT

Click and hold **SPLIT** again until a beep sounds. The keyer memory is still active while in these modes, so be sure to hold the switch closed long enough as to not send the message (if there is one stored)

NOTE: Since there is no visual indication RIT/XIT is active, be sure to exit RIT or XIT mode before starting to tune around the band again!

MENU:

This switch is used to access the various options available. Clicking and **holding closed** the menu switch will scroll through the options. A single Morse character will be annunciated by the side tone to indicate the option. Release the menu button after the desired option character sounds, and before the next, to activate that option. Note that the MENU switch must be held closed for 1 second before the Set Speed options letter "S" is annunciated. If the switch is released before 1 second has elapsed, the frequency reads out.

Options are selected in the following order:

1. **F** – **F**requency readout
2. **S** – **S**et Keyer Speed
3. **E** – **E**nter Frequency Entry (Skipped if in Straight key mode)
4. **T** – **T**une Mode (Skipped if in Straight key mode)
5. **M** – **M**enu Memory Mode (Skipped if in Straight key mode)
6. **P** – **P**rogram user preference, Iambic A/B mode, Morse annunciation speed.
7. **X** – **eXit** menu selections

Frequency readout: (F)

A short, quick click of **MENU** switch will annunciated the current operating frequency in Morse by the side tone. Zeros are sent as the cut number "T" (dash) and the 100 Hz digit is separated from the kHz digits with an "R". Therefore, the frequency 7.0400 will be sent as "T4TRT" When in RIT or XIT mode, the 100 kHz digit is replaced by the letter R or X, and the frequency indicates the amount the current frequency has moved from the initial operating frequency.

Set Keyer Speed: (S)

Keyer speed can be set from between 10 and 30 wpm, in 1 wpm increments. (power up, 20 wpm) **Dash paddle** increases speed. **Dot paddle** decreases speed.

A dot will sound at the new code speed each time it is changed. A dash will sound when the upper or lower speed limit is reached. Speed mode automatically exits when paddle or switches left open for a second. The selected code speed is stored in memory, so the rig will power up at the last used code speed setting. Alternately, the **Tune up** (increase) or **Tune down** (decrease) switches can be used. This allows for changing the code speed if the rig is in Straight key mode.

Measured code speeds: Speeds measured using dots per minute / 25 method.

10.60, 11.76, 13.44, 14.40, 15.32, 16.16, 17.16, 17.68, 18.76, 19.52, 20.16, 22.56, 23.56, 23.64, 24.64, 25.80, 27.00, 28.44, 29.92, 31.56 WPM

Direct Frequency Entry: (E)

This mode allows you to jump directly to a desired operating frequency by entering it in with the paddle. This can be any frequency between 000.0 and the upper band limit for the installed band module. If you key in a frequency greater or equal to the upper band limit, DFE mode will be exited and the frequency remains where it was.

Key in all four digits, 100 kHz digit first. Zeros can be entered full length or as the cut number "T". If a character is not recognized as a valid number, a "?" will be sent and that number needs to re-entered. Once all four digits have been entered, the rig will jump to that frequency and the new frequency will be annunciated by the side tone. This mode can be escaped by clicking the MODE switch anytime before all four digits have been entered. DFE mode is not available when RIT or XIT is active.

Antenna Tune Mode: (T)

This mode is used to facilitate adjusting an antenna tuner, or taking a power output reading. The transmitter is toggled on and off by using the paddles. Tapping the **DASH** paddle toggles the transmitter ON. Tapping the **DOT** paddle toggles the transmitter OFF. When finished with tune mode, return to normal operation by clicking **MENU**.

Enter Keyer Memory Mode: (M)

In this mode, a message is keyed into memory, using the paddle. "Ideal" timing is used to determine letter and word spacing. If you do not pause sufficiently between letters and words, the message will come out garbled. To insure inserting word spaces, it is a good idea to pause slightly longer than you might otherwise do so between words.

Up to 124 characters (including word spaces) maybe stored in the memory. This can be divided up into three separate messages. All the messages must be entered at the same time. To indicate a new message is to be started, key in seven (7) dashes, then continue with the next message.

Review and storing the message:

Once the message(s) have been keyed in, click the **MENU** button. The message(s) will now be repeated, so you can hear if they were keyed in properly or need to be re-entered. If more than one message was entered, you will here the eight dash break separating the messages.

If the message(s) play back the way you want to hear it, click the **MENU** button again to store the message(s) in Flash memory. If you need to re-enter the message(s), press the **RIT** button. The side tone will annunciate "EM" for Enter Message" and you can start to key in the messages again. If more than one message is desired, they all have to re-entered. Repeat as needed until you get it all right and press **MENU** to store.

Sending the message from memory:

A short click of the **RIT** switch will start sending message 1. Message 2 is sent if the **TUNE DOWN** button is clicked within 1/3d second of releasing the **RIT** switch. Message 3 is sent if the **TUNE UP** switch is clicked within 1/3d second of releasing **RIT**.

Stop, Pause and Beacon Mode:

Once the message has started sending, the paddle can be used to stop, pause or enable beacon mode. Paddle state (open/closed) is tested during letter spaces.

Pause:

Close and hold the **Dash Paddle**. Message will pause once a character being sent is finished. Releasing the Dash paddle will resume sending of the message.

Stop:

Close and hold the **Dot paddle**. This will terminate the sending of the message, once a character currently being send it finished. If sending a message in Straight Key mode, closing the SK will also stop the message at the first letter space.

Beacon Mode:

Close and hold the **Dash Paddle** to pause message. While holding closed the Dash paddle, tap the **Dot paddle** closed. A “beep” will sound in the side tone and beacon mode initiated. There is a fixed 4 second delay at the end of the message before it starts to repeat. Using the paddle during the pause will terminate the beacon mode and jump directly into keying the rig. Pause and stop functions work as above while the message is being sent. Beacon mode may also be enabled by using the menu switch. Click and hold the Menu switch as the message is being sent as above.

NOTE: Beacon mode can only be used with message 1. If it beacon mode is enabled while sending message 2 or 3, message 1 will still be sent.

Program User preferences: (P)

Iambic keying mode: The **Tune Down** switch will toggle between mode A and B. The letter A or B will be annunciated to indicate which mode will be active.

Annunciator code speed: Clicking the **Tune Up** switch will store the current keyer speed to be used for all non transmitted Morse character annunciations, AFA, Menu selections, etc.

Once your selections have been made, store them by clicking the **MODE** switch.

Iambic A and B modes

When using Iambic or “squeeze” keying, that is, both paddles are closed at the same time, the keyer produces alternating elements, starting with the element which was closed first. In “A” mode, the keyer will stop sending when the paddles are released and any element which is currently being send is finished. In “B” mode, if both paddles are closed at the very start of a space, an opposite element will be tacked onto the end of the string when the paddles are released. If an extra element is not desired, release the paddles before the start of the space.

Straight Key Mode:

The rig will automatically enter Straight Key Mode if a monaural plug is used in the paddle jack on power up. As noted above, menu options which require a paddle to use are locked out in Straight key mode. If a message has been programmed into memory, it can be used as usual. The code speed at which the message is sent can be changed by using the Tune up and Tune down switches, by first selecting the Code Speed option with the Menu switch.

MENU function cheat sheet

Frequency 100 kHz first, 100 Hz last, "R" before 100 Hz
S – Keyer speed Dash/Tune up increase Dot/Tune down decrease
E – Direct Frequency Entry (use paddle) Menu to escape
T – Tune mode, dash on / dot off MENU to end
M – Keyer Memory Memo – review / RIT- re-enter / Menu – Store
P – User preferences Tune up – toggle A/B iambic mode Tune down – current code speed for annunciations Menu – store and activate

Printed out, this will fit inside the lid of an Altoids tin.

Various considerations:

SWR

The ATS-3 transmitter can be keyed into an open circuit (no antenna connected) indefinitely. It will also tolerate a short circuit for a short period of time, say 30 seconds. Highly reactive loads need to be avoided. These can possibly cause the PA stage to become unstable. Although the PA is protected by a 47 volt zener diode, it may not be sufficient to protect them in all cases. If your antenna needs to be tuned by a transmatch, use the lowest amount of power output practical. The risk of damage due to high SWR goes up as the power output goes up. The use of a resistive SWR bridge will ensure the transmitter sees a reasonable load at all times. You could also use a more robust transmitter to preset the transmatch or use an antenna analyzer.

Paddle jack wiring:

"Standard" wiring is used. Dot = tip, Dash = ring, Sleeve = ground.

Power Supply:

The rig is optimized to operate on a 9 volt supply. A single 9 volt battery will power the rig for several hours, including a fair amount of transmitting. A battery pack made up of "AAA" or "AA" batteries will give progressively longer operating times. Since the rig will operate down to 6 volts, this means the batteries can be used to their limit. If you wish to use a Gell Cell or bench supply, the voltage should be reduced to 11-12 volts. This can be done most simply by using a string of 1A rectifier diodes in series with the supply line. Each diode will drop the voltage about 0.7 volts when transmitting. Additional diodes could be added to drop the voltage into the 9 volt range when adjusting a transmatch, then shorted out with a switch for higher power when the SWR is at safe levels. One could also build an adjustable voltage regulator to have better control of the power output level.

Add a fuse! As is typical with most QRP rigs, the power supply is not internally fused. It would be a very good idea to add an in-line fuse to the supply powering the rig. A ½ amp, fast blow fuse should be sufficient for all transmit power levels, though the transmitter will draw more than ½ amp at the higher power output levels. The fuse will keep the MOSFET PA voltage keying transistor from burning out should the PA fail. It may also help prevent the PA from failing from over current due to high SWR.

DC Power plug – Mouser part # 171-3218 .7mm

IMD problems.

The ATS-3A has an improved QSK switching circuit and uses double tuned receiver inputs on 40 and 30 meters to reduce or eliminate IMD problems from SWBC stations. This was a problem for some users of the ATS-3. Users of the rig in Europe might still experience problems with IMD, despite these changes. This will likely be due to simple overloading of the SA612 mixer, for which there is no easy solution.

Before you starting building the kit:

- **Before you start “melting solder”, be sure to read through all the assembly instructions.**
- Even if you can use a PC or laptop at your work area, its a good idea to print out the assembly instructions for easy reference. Your less likely to miss something important this way. You don't have to print out this entire document, just the pages you need.
- If you have never worked with surface mounted parts before, read the “working with SMT parts” addendum at the end of this manual.
- When you open the parts bags, put the parts into a soup or cereal bowl. This will help ensure you don't loose any of them.
- Two sizes of solder are supplied. The thinnest, 0.01” diameter, is used with all the SMT parts. The larger solder is for use with the through hole parts. There should be sufficient solder supplied to finish the kit. If however, if you do run out, Radio Shack sells small spools of thin solder.

Replacing lost parts:

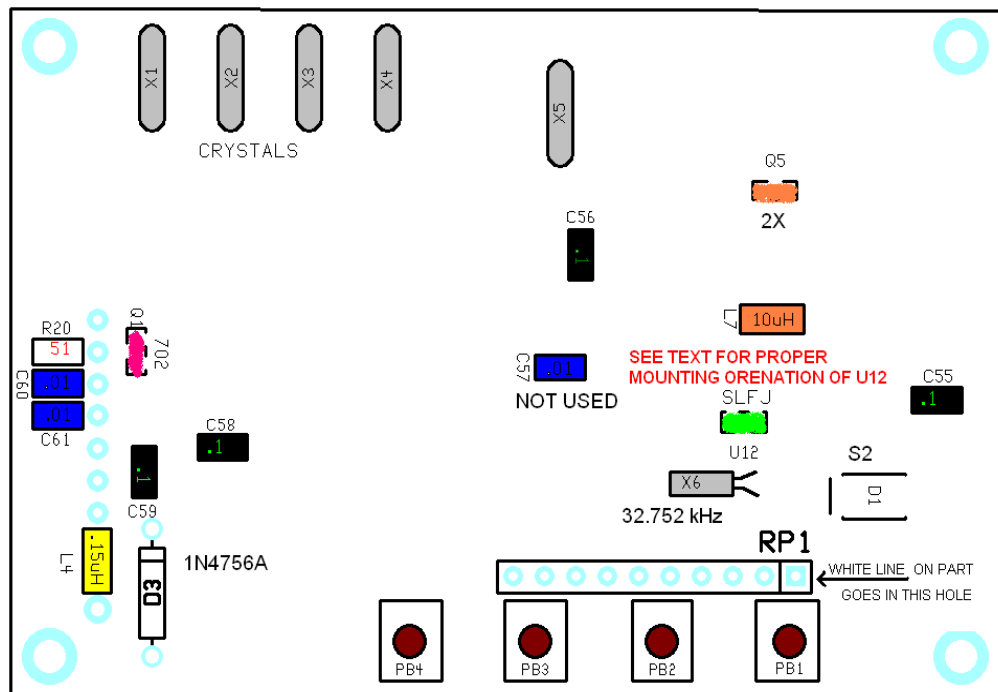
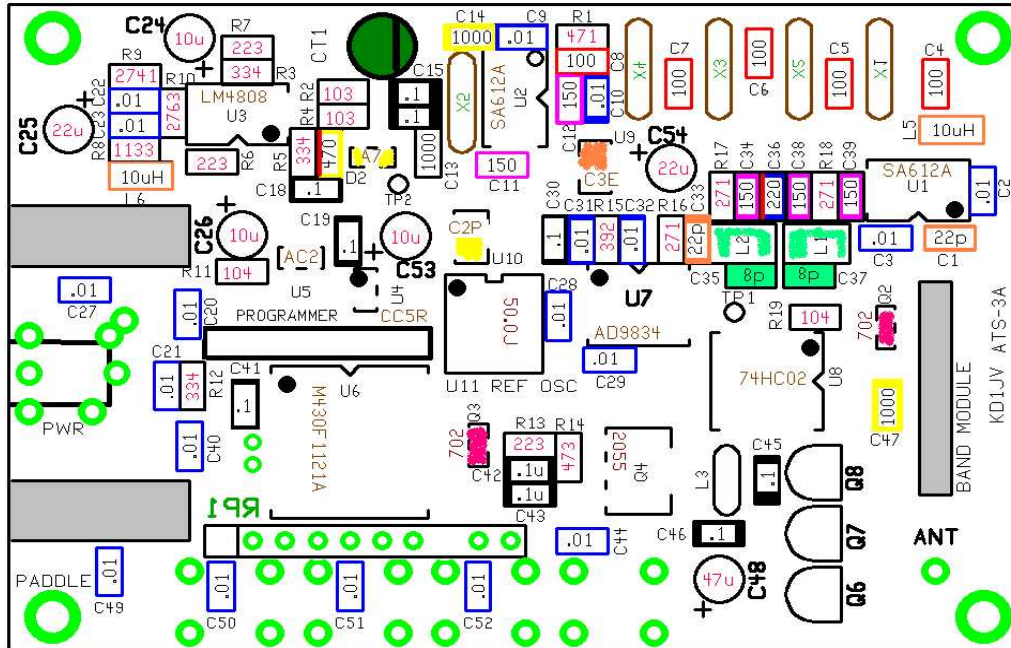
If a part gets lost, (be careful with those tweezers!) it can be replaced most quickly by sending a SASE to me with a note indicating what it is you need. Send the SASE to :

Steven Weber
633 Champlain St
Berlin, NH 03570

Getting help:

I can be contacted at kd1jv@moose.ncia.net by email for help in answering questions about assembly or trouble shooing. Trouble shooting by email can be difficult. Try to make you questions as specific as possible, and try to narrow down the problem area as best you can first. If you get into real trouble, you can return the kit for repair, but there will be a fee for this service. Price depends on circumstances.

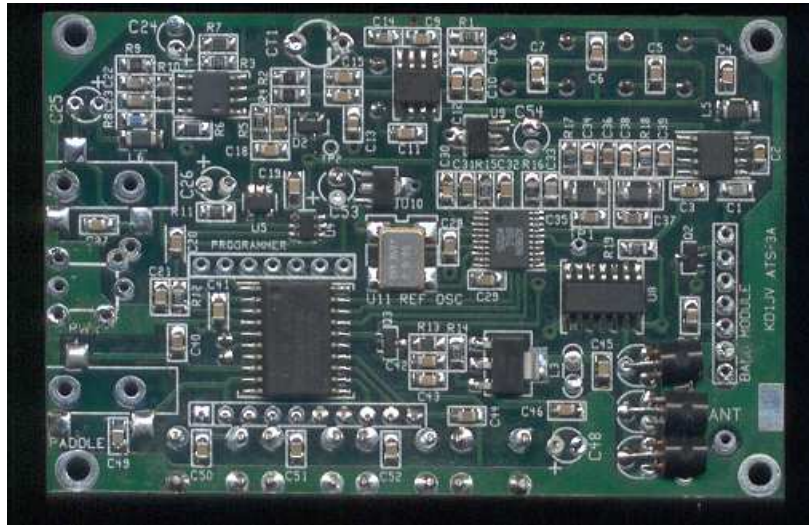
Parts placement over view, Print this page for handy reference while building



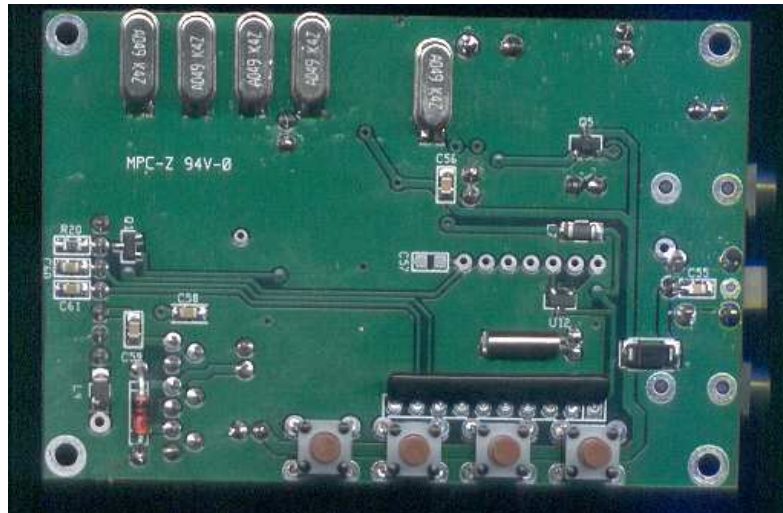
Board photos.

Top side of board.

Only SMT parts shown, since the page scanner doesn't have enough depth of field to make a clear scan of the board with the through hole parts spacing it above the scanner bed. (Not that this scan is all that clear – I believe it has trouble dealing with all the shiny solder)



Bottom of board.



Note: U12 shown mounted incorrectly in this picture.

Semiconductors.

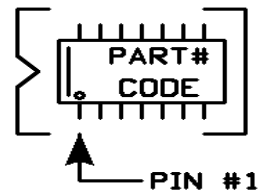
The semiconductors will be soldered in place first, as the pins on some of the ICs can be difficult to access once the chip caps and resistors are soldered down around them.

Static considerations:

Nearly all the semiconductors are sensitive to static damage, aka ESD. It is a good practice to treat them all as if they were. Those that live in high humidity areas have little to worry about here. However, those of us who live in cold, dry, low humidity climates (and run forced hot air heat) need to take some precautions. Wear cotton cloths. Discharge yourself to an electrical earth ground or large metal object before handling the semiconductors. Consider running a humidifier near your work area if you have static problems in your house.

Finding IC Pin 1.

Only three of the ICs (U3/6/7) have a dimple marking Pin 1. With the remaining ICs, you will have to go by the way the writing is printed on the part. When the printing is orientated so that it reads "proper", i.e., left to right, top to bottom, **Pin 1 is ALWAYS in the LOWER LEFT CORNER**. Often, the manufacturers logo will appear at the pin 1 location, there maybe a line on the pin 1 end, and on many parts, the pin 1 side of the package has a slight bevel to it. Pin 1 is mounted on the board facing the notched end of the outline. Pay attention here, as Pin 1 faces in different directions.



Diodes: D1 is in a rectangular package and the cathode end is marked by a white line. D1 gets installed later on the bottom of the board. D2 is a dual diode in an SOT-23 package and identified by a Yellow sticker, so it won't be confused with the other transistors in similar SOT-23 packages.

Transistors: These small parts have three leads, two on one side and one in the center of the other. Since several different types are used, these identified by a color sticker on the back of the plastic part carrier and match the color shown on the layout diagram on the next page. When soldering, be careful not to put any sideways pressure on the leads, or they may break internally in the package.

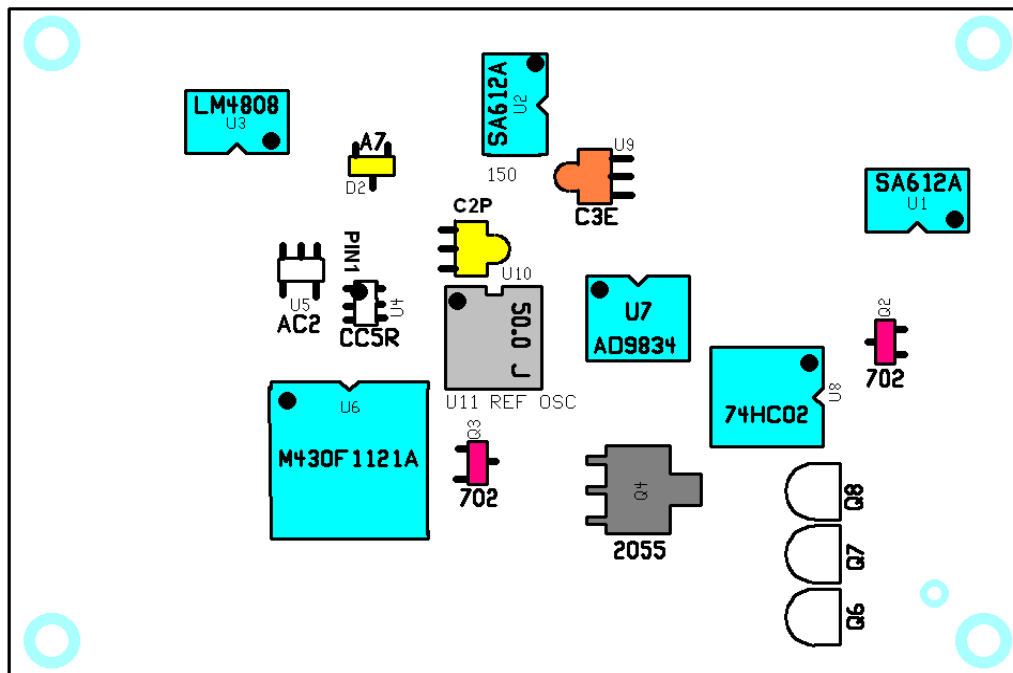
Regulators: To make them easier to identify, the 3.3 V regulator (U10) has been marked with **YELLOW** sticker and the 5 volt regulator, U9 with an **ORANGE** sticker. You don't want to mix these up! Center the body of the package in the outline on the board. If soldered too far forward, it's possible for the center tab to short to the outer lead pads.

Clock Oscillator: U11- This is the little silver box. Pin 1 is marked with a faint dot, or go by the printing, just like ICs. Soldering is a little tricky, be sure to make it wick onto the pads on its sides. A common reason there is no DDS output is failure to get a good solder connection to the clock oscillator pins.

U4. Careful attention is required for this part. Having three legs on each side, the orientation isn't obvious without carefully looking for the dot marking the pin 1 end of the chip.

U5. Orientation of this part is obvious, due to the fact it has three legs on one side and two on the other.

Placement diagrams on next page.



Pin 1 of U4 (CC5R) is in upper left corner, a little hard to see in picture.
 Q6,7,8 get mounted later in assembly.

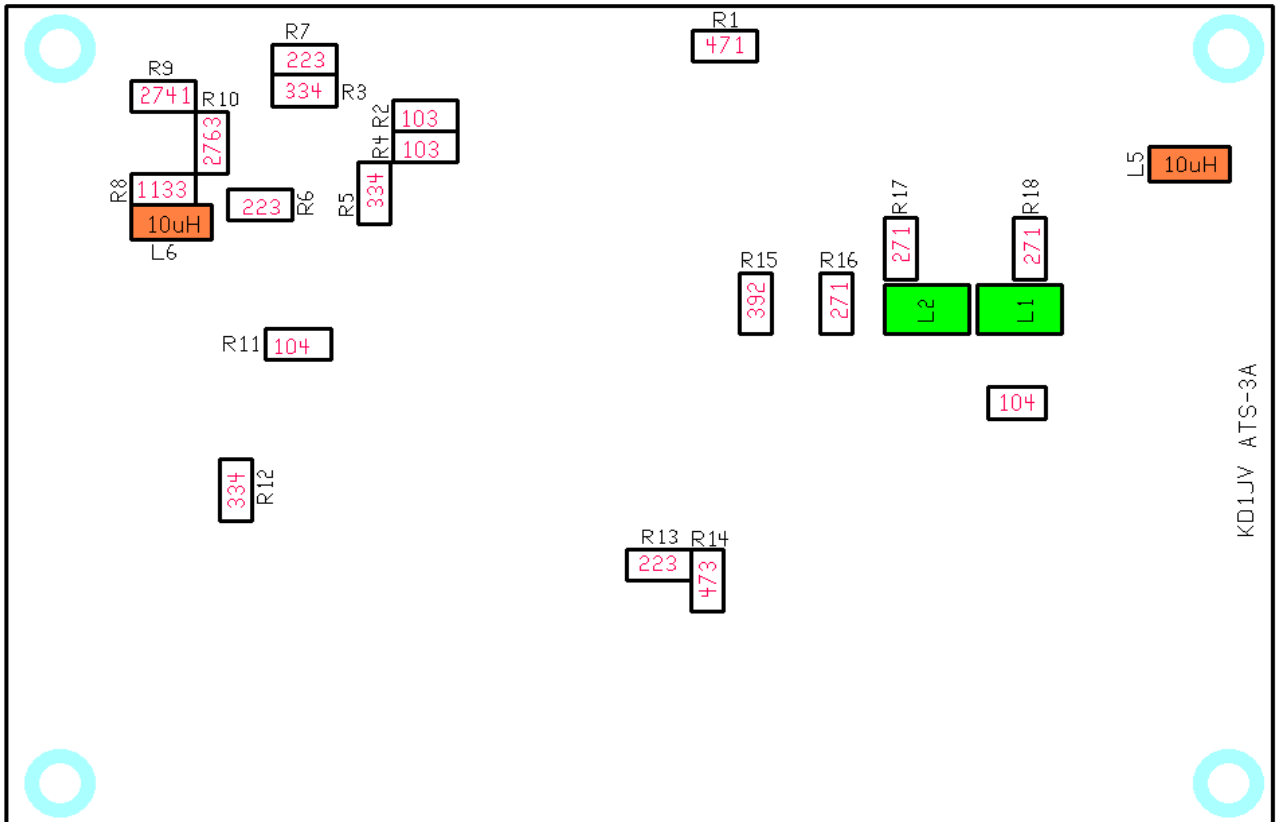
When your finished, with the top side, you'll have a few left over parts. Put these back in the anti-static bag for use later on the bottom of the board.

Resistors:

Resistor carriers are not color coded. Use of a magnifying glass maybe needed to aid in reading the part value. 5% parts use three numbers, 1% parts use four numbers.

Inductors: There are four inductors on this side of the board. These parts are a solid gray in color. The value is not marked on the part, so a color label has been stuck to the carrier to identify them. See table. Inductors are in a plastic carrier, don't confuse them will caps marked by the same color. Caps are in a paper carrier and are smaller.

Top side resistors and inductors:

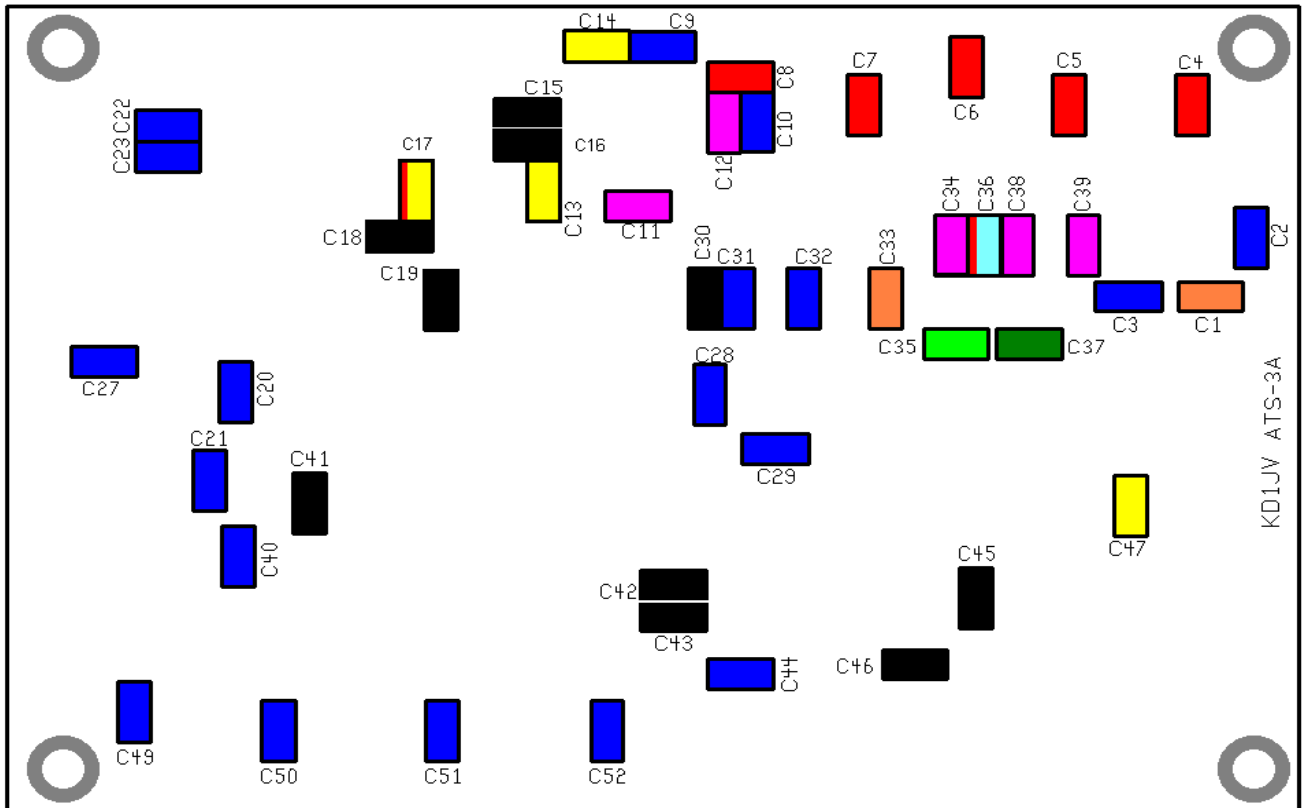


Put 50 ohm (500) resistor in bag with left over semiconductors for use on bottom of board.

LOCATION	VALUE	MARKINGS	LOCATION	VALUE	MARKINGS
R1	470 OHMS	471	R14	47 K	473
R2,R4	10 K	103	R15	3.9 K	392
R3,R5,R12	330 K	334	R16,17,18	270 OHMS	271
R6,R7,R13	22 K	223			
R8	113 K, 1%	1133	L1,L2	1.5 uHy	GREEN
R9	2.74 K, 1%	2741	L5,6	10 uHy	ORANGE
R10	267 K, 1%	2673			
R11,R19	100 K	104			

Capacitors: TOP SIDE

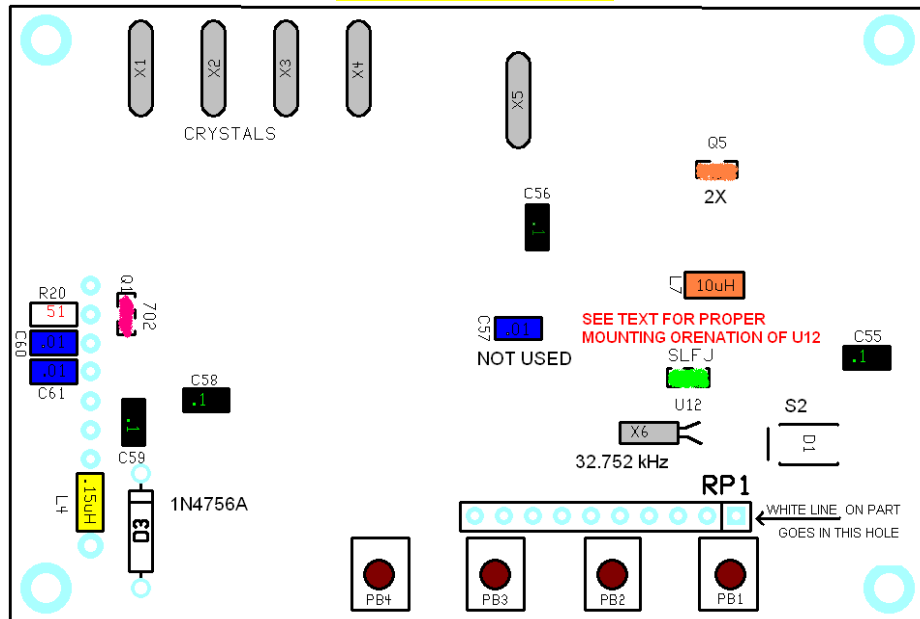
Since capacitors do not have their values marked on the part, the carriers have been color coded and correspond to the colors shown in the layout diagram. Therefore, all you have to do is match the colors. Work with only one value part at a time, so you don't mix them up.



Snip four (4) black and two (2) blue caps from strip to use latter on bottom of board.

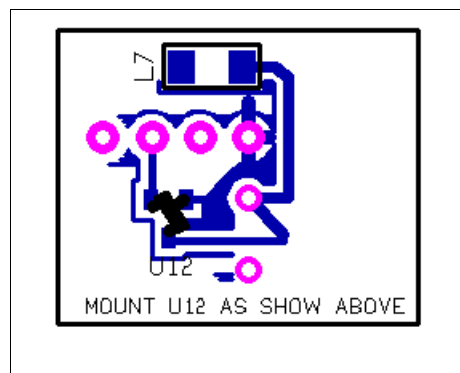
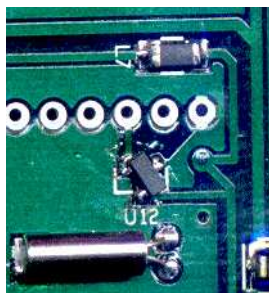
<u>BLACK</u>	<u>0.1 uF</u>	C15, C16 (not labeled on board), C18, C19, C30, C41, C42, C43, C45, C46
<u>BLUE</u>	<u>0.01 uF</u>	C2, C3, C9, C10, C20, C21, C22, C23, C27, C28, C29, C31, C32, C40, C44, C49, C50, C51, C52
<u>RED</u>	<u>100 pF</u>	C4, C5, C6, C7, C8
<u>VIOLET</u>	<u>150 pF</u>	C11, C12, C34, C38, C39
<u>YELLOW</u>	<u>1000 pF</u>	C13, C14, C47
<u>ORANGE</u>	<u>22 pF</u>	C1, C33
<u>GREEN</u>	<u>8 pF</u>	C35, C37
<u>LIGHT BLUE/Red stripe</u>	<u>220p</u>	C36
<u>YELLOW/Red stripe</u>	<u>470 pF</u>	C17 (not labeled on board)

Bottom Side Parts



R20	51 ohms	(510)	
C60,C61	.01uF	BLUE	
C55,C56,C58,C59	.1uF	BLACK	
L7	10uH	ORANGE STICKER	
L4	.15uH	YELLOW STICKER	
Q5	MMBT4401	ORANGE STICKER	Part marked "2X" on package
Q1	2N7002	PINK STICKER	Part marked "702"
D1	SS12 diode	Faint line on end of part goes towards line on board	outline Part marked "S2", number under this is date code.

Mounting U12: An error was made on the board layout, so this part has to be mounted in a different orientation than what is normal and the silk screen outline shows for the part. Basically, it is rotated counter clockwise one set of pads, so that the side with the single lead gets connected to ground, as shown below.

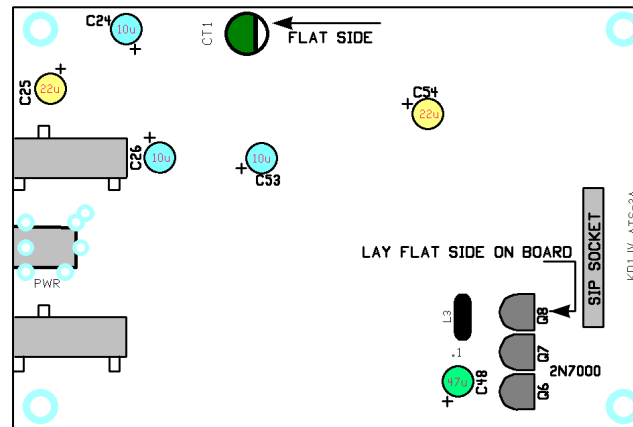


That does it for all the SMT parts. Continue with installing the through hole parts for this side of the board, as listed on the next page.

Bottom side through hole parts

- X6 32.752 kHz crystal. Small silver cylinder. Tack solder edge of crystal to tined pad.
- D3 Glass diode Solder from bottom side of board and clip lead as flush to top side as possible. Soldering lead to ground plane takes a lot of heat.
- RP1 47K SIP resistor pack. **Make sure white line or dot on end of R pack goes in the boxed-in hole on outline, or it the rig will not work properly.** Also angle the package away from switches by about 45 degrees before soldering in. Clip excess lead length.
- X1-5 4.9152 MHz Crystals. All xtals matched to +/- 10 Hz. Solder pads at end of crystal case can be used to ground case.
- PB1-4 TACK PB switches. These will only go in one way. Clip excess lead length.

Top side through hole parts:



SMT stereo phone jacks.

Power jack, 0.7 mm

CT1 Green trimmer cap. Be sure to put flat side facing line on outline.

Watch polarity, of the electrolytic caps, long lead is plus side.

C24, C26, C53 10 uF electrolytic cap. (light blue locations)

C25, C54 22 uF electrolytic cap. (yellow locations)

C48 47 uF electrolytic cap. (green location)

Q6/7/8. 2N7000 TO-92. Mount laying down with flat side of package pressed against board, as shown in photo on page 12.

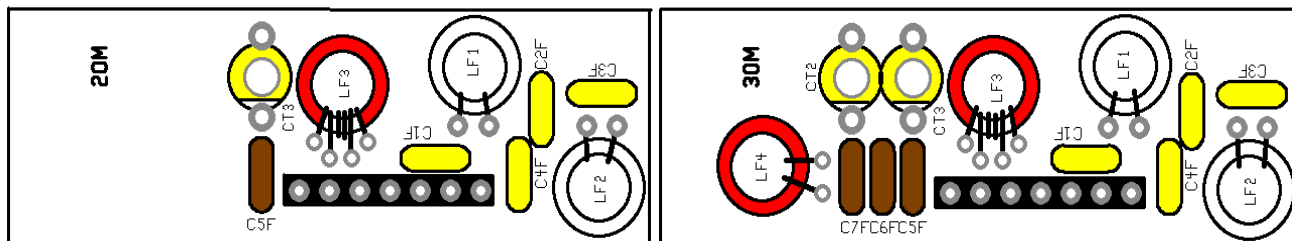
SIP socket, 7 pins. Make sure socket is square to board before soldering more than one pin.

L3 13 turns #26 wire on black FT37-43 core. Wind the core, but don't install it yet. Do this after initial board tests.

Assembly of the main board is now complete.

Filter boards:

The band for which each filter board is to be used on is printed on the board. This is because the MPU will read a code from the board to determine which band is in use. Therefore, you must ensure the parts for the 80 M band go on the 80 M board and so on.



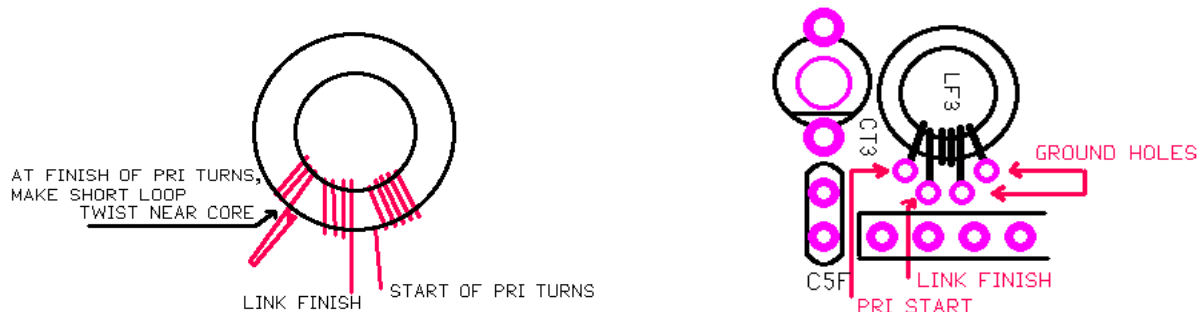
The filter boards come attached to each other and simply snap apart along the scored cut. Note that the 40 and 30 meter boards are slightly different from the 80 and 20 meter boards. An example of each type is shown above.

Install the caps first, then the coils, and finally the SIP pins. All parts are installed on the component screened side of board, including the SIP pins. See photo on next page. When the filter board is installed into the main board, the parts will be upside down. Trim all leads after soldering, including the SIP pins, as flush as possible. Otherwise, the leads might short to the lid of the tin when it is closed.

Be sure to install the trimmer caps with the flat towards the line on the board outline. The spacing between the two trimmer caps on the 30 and 40 meter modules ended up a little closer than it should have been. Because of this, at least one of the trimmers will be "cocked" a little to one side. This will cause the screwdriver access hole for adjusting the trimmer a little out of line with the part. Before you mount these trimmers, if you have a small round file, elongate the side of the hole slightly to make it easier to fit a small screwdriver to adjust cap with.

Wind the wire for the toroids fairly snug to the outside of the core, or the wire lengths won't be right. Lengths assume no more than 1/2" starting pig tail. Remember, one pass through center of core is one turn. LF3 has a link winding for coupling into the coil. When you finish winding the primary turns, make about a 1/2" loop and give it a couple of twists at the side of the core. Then continue to wind the link. When the link turns are finished, leave the wire for the link a little longer than the wire which starts the primary turns, so you know which end is which. On the 80 meter coil, there is not much room to wind the link, so don't worry if you have to overlap turns to make it fit.

The ends of the turns which you made a loop with go into the grounded pads. This way you don't have to determine which end is for which winding. See diagram below.



<i>loc</i>	<i>80M</i>	<i>40M</i>	<i>30M</i>	<i>20M</i>
C1F	680p (681)	330 p (331)	220 p (221)	150p (151)
C2F	1500p (152)	680 p (681)	560 p (561)	330p (331)
C3F	220p (221)	100 p (101)	68 p (68)	33p (33)
C4F	680p (681)	330 p (331)	220 p (221)	150p (151)
C5F	100p (101 disk)	47 p (47 disk)	Not used	22p (22 disk)
C6F	Not used	2.2 p (2.2 disk)	2.2 p (2.2 disk)	Not used
C7F	Not used	47 p (47 disk)	Not used	Not used
CT2/3	Brown trimmer	Yellow trimmer	Yellow trimmer	Yellow trimmer
LF1	23 Turns #28(12.5") RED T30-2	15 Turns #26 (8") RED T30-2	12 Turns #26 (7") RED T30-2	11 Turns, #26 (6") Yellow T30-6
LF2	24Turns #28 (12.5") RED T30-2	17 Turns #26 (9") RED T30-2	14 Turns #26 (7 3/4") RED T30-2	15 Turns #26 (8") Yellow T30-6
LF3	60 T #32 Red T37-2 36" 10 T #32 link	40 T #28 on red T37-2 24" 5 T #28 link	40 T #28 on red T37-2 24" 5 T #28 link	30 T #28 on red T37-2 17" 5 T #28 link
LF4	Not Used	40T (21") #28 on red T37-2	40T (21") #28 on red T37-2	Not Used

#32 is thinnest wire, #28 is gold in color, #26 is red.

Band filter parts table. Two 39 pfd caps will be left over, turns out their not needed.

Photos of assembled filter boards:



Check out and Calibration:

Clean the board of any flux residue. This will help in inspecting all the solder connections. Using your magnifier, inspect all the solder connections, looking in particular for any you might have missed making. Hopefully, you have all the ICs installed with the proper orientation and location, as this type of error is not easy to correct. Same goes with the caps, as it's now difficult to verify their correct values.

- Use an ohm meter to check for shorts across the DC in, +3.5 and +5 regulator outputs to ground and between the regulator outputs and DC in, for both the 3.5 and 5 V regulators.
- Find and eliminate short if one is detected.
- Wire up a 9V supply to the power plug (Use 9V battery or current limited supply (set to 100 ma limiting) to start. This way, if there is a problem, its unlikely any damage will result from too much current being drawn.
- Plug a set of stereo headphones into the headphone jack.
- Plug in the power supply
- You should hear the power up message "20M" in the headphones. If you hear this message, you know the processor and audio amp are working fine.
- Check the voltage at TP1, it should be about 4 volts. If not, check connections on R19.
- Check the voltage on the PA gates, Q6 to Q8. This voltage should be zero (0) volts. If it is not, check solder connections on U8 pins.
- Plug a paddle into the paddle jack and send some dits and dahs. You should of course, hear them in the headphones.
- Connect a voltmeter between ground and the Drain of Q4, the PA keying transistor. (Large metal tab is Drain).
- Send a string of Dahs and watch the voltmeter. It should go to near the DC supply input voltage. It should then slowly decay to zero when you stop sending. This is the voltmeter discharging the .1 uF bypass cap. Check the soldering in the keying circuit if there is a problem.
- Remove power from the board.
- You can now install L3.

Reference Oscillator Frequency Calibration:

The "ideal" reference frequency of 50.000000 MHz is initially assumed to calculate the DDS VFO frequency. In practice, the reference oscillator has a +/- 20 ppm tolerance. This calibration is provided to adjust the value of the reference frequency used in the calculation to exactly match the actual oscillator frequency and therefore produce the exact expected operating frequency. If you have no means of accurately measuring 10 MHz, skip through this procedure by clicking the MENU switch after step 6 and go directly to the LO cal procedure. Even if left uncalibrated, the frequency error will be pretty much trivial.

1. Click and hold closed both the RIT and Tune Up switches.
2. Apply power.
3. "V1" should be heard in the headphones. This is the firmware version number and can be used to determine which firmware version is in the rig. If the firmware has been updated, the number will change from 1 to 2 or 2 to 3 and so on as changes are made. (not that there will be, hi!)
4. Continue to hold closed the RIT and Tune up switches. Releasing the switches before the next CW annunciation will jump to normal power up sequence.
5. "CF" should be heard in the headphones.
6. Release the switches.
7. Connect a frequency counter to DDS TP1.
8. Using the tune up and tune down switches, adjust the frequency at TP1 to exactly 10.000,000 MHz.
9. Once the frequency is adjusted, click the MENU switch to store the new reference frequency.
10. The side tone will now announce "CO" A low pitched tone will be heard in the headphones.

Local Oscillator frequency trim:

This is used to trim the LO frequency to exactly match the center response of the IF crystal filter. This will ensure the best sensitivity of the receiver. This adjustment is made with the help of an Oscilloscope. If one isn't available, It's possible to use your PC with an audio spectrum scope program. You can solder a short wire to TP2 and one of the headphone jack pins to hang a clip lead onto. If you don't have a 'Scope, skip to step 7 and peak the audio tone using the BFO trimmer by ear.

1. Connect a 'Scope to TP2 (pin 1 of U3) (2V / div, 1 ms / div sweep)
2. Preset the BFO trimmer cap (CT1) by giving it about a ¼ turn.
3. You should hear a pretty loud tone in the headphones.
4. Repetitively click the Tune Down switch to step the LO frequency through the pass band of the filter. Note when the signal at TP2 starts to decrease. Now start clicking the Tune Up switch and keep track of how many steps it takes before the signal starts to decrease again. This tells you how wide the filter is. (Each click (step) tunes about 10 Hz.) Divide the number of clicks by 2, then re-tune with the Tune Down switch that number of steps. The LO frequency will now be set to the center of the pass band of the filter.
5. Move the input to the Scope to one of the headphone jack pins.
6. Adjust the green BFO trimmer cap, CT1, and peak the audio signal at the headphone jack. This centers the beat note in the audio band pass filter.
7. Click the MENU button again to finish the calibration. The rig will reset and restart.

If the above calibrations worked, you know everything but the transmitter and filter boards are working properly. You can now go onto the testing and adjusting the band filters. Otherwise, go to the trouble shooting guide on page and track the reason the rig isn't working down.

Band filter test and adjustment:

Turn the power to the rig off and insert a band module. Temporarily connect an antenna jack to the antenna pad and ground on the main board, using short wires or coax. If possible, use regulated 9.0 volt supply or "AA" battery pack with new batteries.

1. Connect an antenna or signal generator to the antenna input.
2. Power up the rig. Peak the Rx input trimmer cap or caps for best signal or peak band noise.
3. Turn rig off.
4. Disconnect the antenna and connect a power meter and dummy load.
5. Insert a straight key or paddle into the paddle jack. If using a paddle, hold the DASH paddle closed when turning the rig on, and hold closed until you hear the band annunciation. After that, the DOT paddle will work like a straight key.
6. Turn power back on. Key the rig and note power output. With a 9.0 V supply, power output should be between 2.5 and 2.9 watts, depending on the band. With a 12.0 V supply, power out should be between 4 and 5 watts out.
7. If power output is off significantly, check capacitor values in the filter and number of turns on the coils. Make sure your using a watt meter which is accurate at these power levels.
8. Power output can be adjusted to some extent by changing the spacing of the turns on LF1 and LF2. You can remove and insert the filter board with power to the rig on, though moving the coils to the top of the board makes things easier. Ideally, you should shot for about 2.5 watts out on all bands, using a 9.0 V supply.

If you've gotten this far, Congratulations! Everything seems to be working and you can mount the rig into a tin and start operating.

Troubleshooting:

Hopefully, your rig performed flawlessly during the above tests and calibration. Unfortunately, this is not always the case. Specific trouble shooting advice is hard to give, the best we can do is go over some basics.

99.9% of the time, the reason a kit does not work is due to soldering issues. Therefore, this is the first thing to look for. Forgetting to solder one end of a chip resistor or cap is a common mistake. Sometimes, if a component is missing a solder connection, everything might seem to work alright at first, but then a problem shows up later after the board has been handled some. Twisting the board slightly can often make this kind of problem appear and disappear.

Also, sometimes an IC pin looks to be soldered, but the solder is just on the top of the lead and isn't actually connecting to the board pad. One way of identifying this problem is the "wiggle" the lead with the tip of an Xacto blade as see if it moves or not.

If the problem is not obvious from a simple visual inspection, try to localize the problem area. This is preferred to taking the "shot gun" approach of re-soldering everything. If all you have for test equipment is a DVM, you can only do a limited amount of troubleshooting. Ideally, you will have a 'Scope and a signal generator available for more intensive troubleshooting. If you don't own a "Scope, maybe you can find someone local with one who would be willing to help you out.

When using a voltmeter or other probes on the 3.5 and 5 V regulator pins, be very careful. The input and output pins are adjacent, so there is a real possibility of shorting these together. If this happens and the raw DC is put on the regulator output, it will most likely fry all the ICs connected to that supply.

Specific problems:

Dead- Power supply getting to regulators? 3.3 and 5.0 volt outputs from regulators okay?
Measure supply voltages at a place other than the output pin on the regulator it's self.

Power supply okay, no side tone on power up

Check solder connections on audio amp, U3 and surrounding part, headphone connector, side tone filter, R12, C20 and mute switch, U5.

Side tone okay, no audio during LO offset trim cal.

Check connections around mixers U1, U2 and mute switch, U4.
Check for DDS output

No DDS output

Check U7 for shorts between pins or pins not soldered to pads on board.
Check connections on all parts around DDS chip
Check for small DC bias voltage across R16. If there, set up data is getting to DDS chip.
Check connections on 50 MHz reference oscillator.

No audio with antenna connected, okay during LO trim cal

Check solder connections to toroid coil wires. You did remember to tin the wires first, didn't you?

No transmit power out:

Check connections on keying transistors Q3, Q4 and associated parts. Check solder connections on U8. Check for continuity through low pass filter.

Rig resets when you key the rig to transmit, but only when using 30M band.

Resistor pack is installed in wrong direction. It will have to be unsoldered and turned 180 degrees around.

Rig resets when you key to transmit, on all bands.

Battery or power supply soft and voltage dropping low enough to trigger MPU watchdog reset.

IC voltage charts.

Receive mode, no signal, no band module installed

U1 and 2 SA612AD MIXERS

P1	1.4V	RFIN	P8	5.0V	V+
P2	1.4V	RFIN	P7	4.3V	OSC
P3	0V	GND	P6	4.9V	OSC
P4	3.9V	OUT	P5	3.9V	OUT

U3 LM4808 AUDIO AMP

P1	2.2V	OUT	P8	4.4V	V+
P2	2.2V	-IN	P7	2.2V	OUT
P3	2.2V	+IN	P6	2.2V	-IN
P4	0V	GND	P5	2.2V	+IN

U5 AUDIO AGC

P1	0V	Vage	P5	1.3V	Audio in
----			P4	0V	GND
P2	5.0V	V+	P3	0.96V	Audio out

U4 MUTE SWITCH

P1	2.2V	Audio in	P6	3.5V	Control
P2	0V	GND	P5	5V	V+
P3	0V	ST in	P4	2.2V	Audio out

U6 MPS430 MPU

P1	0V	TEST	P20	3.5V	MUTE
P2	3.5V	V+	P19	3.5V	DDS
P3	0V	ST out	P18	3.5V	DDS
P4	0V	GND	P17	0V	DDS
P5	2.7V	osc	P16	0V	Tx key
P6	1.7V	osc	P15	3.5V	Tunedn
P7	3.5V	reset	P14	3.5V	MENU
P8	3.5V	Dash in	P13	3.5V	band
P9	3.5V	Dot in	P12	3.5V	band
P10	3.5V	Tune up	P11	3.5V	RIT

U7 AD9834 DDS

P1	1.13V	FS ADJ	P20	.75V	IOUtb
P2	1.17V	REF out	P19	.37V	IOUtb
P3	3.54V	COMP	P18	0V	AGND
P4	5.0V	AVDD	P17	.37V	CMPin
P5	3.5V	DVDD	P16	3.75V	CMPOut
P6	2.4V	CAP	P15	3.3V	FSYNC
P7	0V	DGND	P14	3.3V	SCLK
P8	1.7V	40 MHz	P13	0V	SDATA
P9	0V	Fsel	P12	0V	SLEEP
P10	0V	Psel	P11	0V	RESET

Packaging the rig:

This rig was designed so that an Altoids tin would be the ideal way to package the rig. The board mounts into the bottom of the tin. The switches are accessed through holes drilled into the bottom of the tin. Therefore, the lid of the tin is the bottom of the rig. This arrangement allows changing the band modules by opening the lid of the tin.

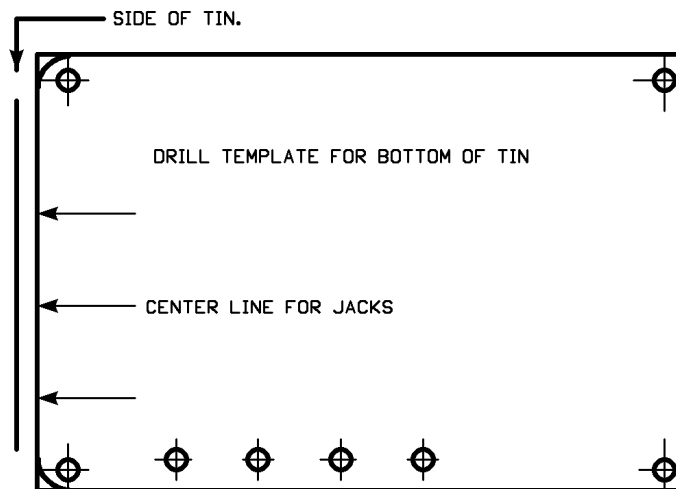
For the board to fit against the side of the tin where the jacks are located, the corners of the board need to be trimmed. The corners of the board can be snipped off with a pair of heavy duty scissors and then rounded with a file.

An RCA jack is supplied for use as an antenna jack. There is enough room on the side of the tin to replace it with a BNC jack if you prefer. Use short lengths of wire to jumper to the antenna output pad on the board and the jack center pin, and from the ground lug on the jack to the tinned ground area near the antenna pad on the board.

3/16" #2 threaded spacers, 1/2" #2-56 screws and nuts are supplied for mounting the board. The screws are a little long, so there is a trick to using them. Thread the spacers onto the screws, leaving just a little bit of the end of the screw protruding past the end of the spacer. Now set the board into the tin, line up the screws in the board holes and add the nuts. By putting a little pressure on the board, you can now tighten the screws, then the nuts.

The drill drawing below can be used to locate the mounting and switch holes. The board sits back 0.1" from the side of the tin. A reference line is used to locate the side of the tin. Trim the template print out to this line. Place the template in the bottom of an Altoids tin and mark the hole locations.

To locate the holes for the jacks on the side of the tin, put the template on the outside, bottom of the tin. (printing down, as its now reversed) Use the jack center line guides on the template to mark the location of the jacks on the bottom edge of the tin. A square can be used to extend these marks up the side of the tin. The holes will be located 5/16" up from the bottom edge of the tin.



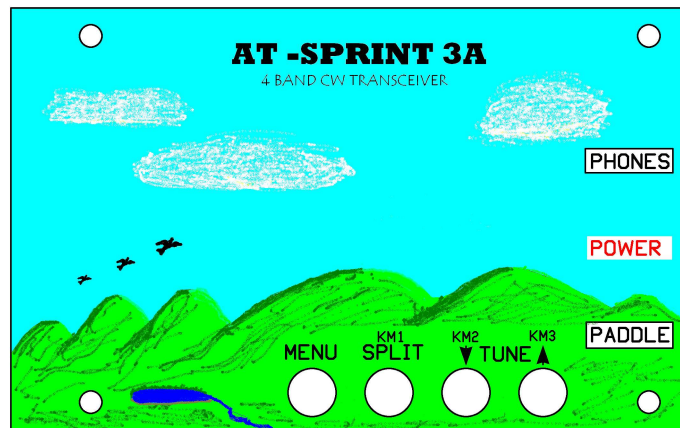
Drill Template

Before mounting the board in the tin, a small piece of felt cloth can be placed over the switches (cut a slot in the cloth for the buttons to stick through). This will help keep dirt and grim out of the box, and possibly getting into the switches. It would also be a good idea to put a piece of plastic in the lid of the tin over the filter board area. This would prevent possibility of the lid shorting to the top of the filter

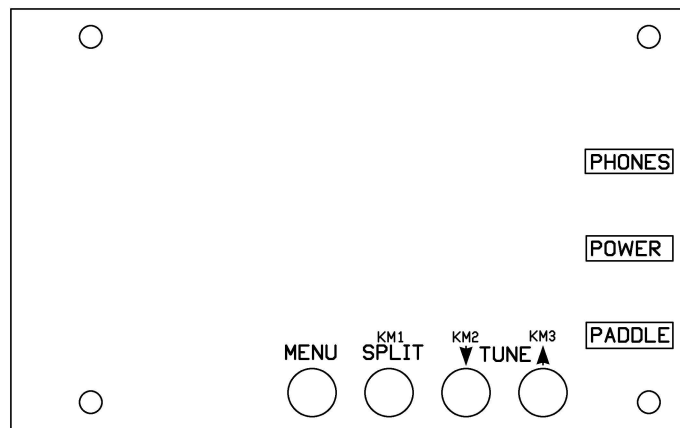
board, possibly resulting in damage to the transmitter if it is keyed. A piece of an old credit card works well for this. I'm sure you have more credit cards than you need and really should cut one up anyway, hi.

Two front cover labels are included on the CD as bit map files. One Label is in black and white, and can be used as the template for making your own design. The other, shown below was colored using MS Paint. As you can see, you can get creative, though Paint is a bit of a pain in the butt to use. Using a label will make the rig look much nicer than just leaving the bottom of the tin as it comes from the store, or using label tape to identify switches and jacks. Some builders of the ATS-3 have made very nice labels.

In order to print to proper scale, open the file with Paint and print from there. For best results, print on photo paper. Once printed, the label can be laminated to protect it and keep water from making the ink jet ink run. Make the holes for the switches with a paper punch. Attach to the tin by using double sided tape around the edges and around the switch holes. This will keep the edges from curling. The four mounting screws will keep the label in place. Trim the corners to conform to the round corners of the tin.



Color label



Generic black and white label

<i>location</i>	<i>value</i>	<i>type</i>	<i>location</i>	<i>value</i>	<i>type</i>
C1	22p	0805 NPO	C32	.01uF	0805 chip
C2	.01uF	0805 chip	C33	.22p	0805 NPO
C3	.01uF	0805	C34	150p	0805 NPO
C4	100p	0805 NPO	C35	8p	0805 NPO
C5	100p	0805 NPO	C36	220p	0805 NPO
C6	100p	0805 NPO	C37	8p	0805 NPO
C7	100p	0805 NPO	C38	150p	0805 NPO
C8	100p	0805 NPO	C39	150p	0805 NPO
C9	.01uF	0805	C40	.01uF	0805chip
C10	.01uF	0805	C41	.1uF	0805 chip
C11	150p	0805 NPO	C42	.1uF	0805 chip
C12	150p	0805 NPO	C43	.1uF	0805 chip
C13	.001uF	0805 chip	C44	.01uF	0805
C14	.001uF	0805 chip	C45	.1uF	0805
C15	.1uF	0805	C46	.1uF	0805 chip
			C47	.001uF	0805 chip
C16	.1uF	0805 chip	C48	47uF	Alum electrolytic 16V
C17	470p	0805	C49	.01uF	0805 chip
C18	.1uF	0805 chip	C50	.01uF	0805 chip
C19	.1uF	0805 chip	C51	.01uF	0805 chip
C20	.01uF	0805 chip	C52	.01uF	0805 chip
C21	.01uF	0805 chip	C53	10 uF	Alum electrolytic 16V
C22	.01uF	0805 chip	C54	22uF	Alum electro 6.3V
C23	.01uF	0805 chip	C55	.1uF	0805 chip
C24	10uF	Alum electro 10V	C56	.1uF	0805 chip
C25	22uF	Alum electro 6.3V	C57		Not used
C26	10uF	Alum electro 10V	C58	.1uF	0805
C27	.01uF	0805 chip	C59	.1uF	0805 chip
C28	.01uF	0805 chip	C60	.01uF	0805 chip
C29	.01uF	0805	C61	.01uF	0805 chip
C30	.1uF	0805			
C31	.01uF	0805 chip			

Parts List

<i>location</i>	<i>value</i>	<i>type</i>	<i>location</i>	<i>value</i>	<i>type</i>	
R1	470 ohms (471)	0805 5%	U1	SA612AD (SO-8)	MIXER	Phillips
R2	10 K (103)	0805 5%	U2	SA612AD (SO-8)	MIXER	Phillips
R3	330 K (334)	0805 5%	U3	LM4808M (SO-8)	AUDIO	National
R4	10 K	0805 5%	U4	74LVC1G3157DBVR	switch	TI
R5	330 K	0805 5%	U5	AM6123MST (SOT-23)	AGC	Panasonic
R6	22 K (223)	0805 5%	U6	MPS430-1121A (SO-20)	MPU	TI
R7	22 K	0805 5%	U7	AD9834BRS (TSSOP-20)	DDS	ADI
R8	133 K (1333)	0805 1%	U8	74HC02M (SO-14)	NOR	STmicro
R9	2.74K (2741)	0805 1%	U9	812C50AUA (SOT-89)	+5V LDO	SEKIO
R10	267 K (2673)	0805 1%	U10	812C33AUA (SOT-89)	3.3V LDO	SEKIO
R11	100 K	0805 5%	U11	3.3 V , 50.000 MHz	50.00 MHz	
R12	330 K	0805 5%	U12	MCP120T-315I	reset	Microchip
R13	22 K	0805 5%	D1	SS12 Schottky diode	1A/20V	Vishay
R14	47 K (473)	0805 5%	D2	BAV99IN (SOT-23)	Dual diode	
R15	3.9 K (392)	0805 5%	D3	1N4756A Zener	47V 1W	DO-41
R16	270 Ω (271)	0805 5%				
R17	270Ω	0805 5%	Q1	2N7002	SOT-23	
R18	270Ω	0805 5%	Q2	2N7002	SOT-23	
R19	100 K	0805 5%	Q3	2N7002	SOT-23	
R20		0805 5%	Q4	NDT2955 (SOT-233)	P MOSFET	Fairchild
RP1	47 K x 8	10 pin SIP	Q5	MMBT4001	NPN	SOT-23
			Q6,7,8	2N7000	TO-92	fairchild
L1	1.5uH	1206				
L2	1.5uH	1206	X1-5	4.9152 MHz	HC-49SUA	
L3	13T	T37-43	X6	32.752 kHz	cylinder	
L4	.15uH	1206	S1-4	Tactile SW 6mm x 7mm		
L5	10uH	1206	J1	7 terminal SIP jack		
L6	10 uH	1206	2	SMT Stereo jack		
L7	10 uH	1206	1	0.7mm PWR jack		
			4	#2-56 3/8" Phillips screws		
1	RCA jack		4	#2-56 nuts		
	Circuit	Boards	4	0.187" 2-56 threaded	spacer	

Filter board parts check list

<i>qty</i>	<i>monolithic</i>	<i>qty</i>	<i>disk</i>
1	1500p (152)	2	2.2 p (2.2)
3	680p (681)	1	22 p (22)
1	560p (561)	2	39 p (39)
3	330p (331)	2	47 p (47)
3	220p (221)	1	100 p (101)
2	150p (151)		
1	100p (101)		
1	68p (68)		
1	33p (33)		
1	70p brn trim		
5	40p yel trim		
4	7 pin SIP		
6	T30-2 (red)	6	T37-2 (red)
2	T30-6 (yel)		

Theory of Operation:

Controller:

A Texas Instruments MSP430 micro controller (MPU) is used to control the rig. This is a 16 bit processor, with 4K of Flash memory, 256 bytes of RAM, two 64 byte "information" Flash memory locations, 15 I/O ports, and internal 4 MHz R/C clock oscillator. The main reason this part was chosen was for its very low operating current, a mere 260 μ amps. An external 32.756 KHz watch crystal is used as a time base for the keyer and side tone oscillator. The internal 4 MHz R/C oscillator has a wide tolerance and is temperature dependent, making it less suitable for exact timing tasks.

The primary function of the processor is to control the DDS chip, which is the VFO for the rig. On power up, the processor looks at two pins on the filter board to determine which band is being used. From that, it then loads constants for the transmit frequency. The actual DDS phase accumulator data is then calculated for that operating frequency, based on the DDS reference oscillator frequency.

At the same time the transmit frequency is calculated, an IF offset is added or subtracted to the transmit frequency. This number is loaded into the DDS chip for use as the receiver's LO frequency. As the receiver is tuned up and down the band, a new phase word is calculated. This ensures that the actual operating frequency and the frequency the Audio frequency Annunciator (AFA) closely match.

The secondary function of the processor is to implement an Iambic keyer, and to handle the various control functions which are needed to switch between receive and transmit. It also generates the side tone.

Power on reset:

The MPU will continue to run down to about 2 volts. Because of the MPU draws very little current, the filter cap across its supply line will keep it going for a while after power to the board is removed. Therefore, to ensure proper reset when power is quickly removed and restored, such as when changing band modules, a microprocessor supervisor reset chip is used to reset the processor when its supply voltage drops below 3.15 volts.

Software listing

There is a file on the CD called "ats3A.s43" which is the program source code. The file can be opened and read by any word processing program. The software source code is included for those who might be interested in seeing what it takes to run this rig. Those who are into assembly language programming may want to get the IAR development package for the TI MSP430 processor so that they can modify and compile the program. The development program can be downloaded from the TI web site for free, but it's a big file. The board for the rig includes a place to connect an in-circuit programmer to (the row of holes above the MPU), so the MPU can be easily reprogrammed with the proper hardware.

DDS

The operating frequency of the rig is synthesized by an Analog Devices AD9834 DDS chip. This is a low power synthesizer, which can be clocked up to 50 MHz. The maximum output frequency in theory is $\frac{1}{2}$ the clock, but in practice it needs to be limited to about $\frac{1}{3}$ to prevent the generation of difficult to filter spurious signals. The AT Sprint II uses a 50 MHz reference clock, so that when producing a 14 MHz signal, it is below $\frac{1}{3}$ the clock. A 5 pole elliptical low pass filter smooths out the stepped DAC output of the DDS and removes harmonics and spurs.

The sine wave output of the filter is used to supply the LO signal to the receiver's first mixer. This signal is also fed back into the DDS chip, into a fast, on chip comparator. This squares up the sine wave to produce a square wave output and is used to drive the transmitter. This output can be conveniently turned on and off by software.

The DDS chip has two major sections inside, the digital side and analog side. This DDS chip can operate with different supply voltages on each section. Therefore, the digital side is powered by 3.3 volts and the analog side 5 volts. By running the digital section with 3.5 volts, lower operating current is achieved. This also keeps any digital noise on the 3.3 volts supply, which also powers the MPU, out of the analog section and reduces spurs. All in all, between the supply isolation, the low operating current of both the MPU and DDS, there is hardly a spur to be heard in the receiver.

Receiver:

The receiver is based on the classic NE602 (replaced by the SA612A) design, used in many QRP rigs. The receiver input signal from the antenna first passes through the transmitters low pass filter. QSK switching is done by using two 2N7002 MOSFET transistors, arranged in a series / shunt configuration.

During receive, Q2 is turned on and Q1 is turned off. Q2 allows the signal to pass from the transmitter low pass filter to the receivers input tuned circuit. R20, a 51 ohm resistor, is used to terminate the LPF so that it behaves properly. Without this termination, the filter response is not as one would expect.

When the rig switches to transmit, Q2 is turned off and Q1 is turned on. Turning Q2 off isolated the receiver input from the transmitter signal. Turning Q1 on shunts any leakage to ground. Q1 is controlled by the transmitter keying port of the processor, and Q2 by the Mute port, as these have opposite logic states and match those needed by Q1 and Q2 for proper operation.

The use of the MOSFET QSK switching greatly reduces or eliminates IMD problems which can be caused by a passive series L/C network with back to back limiting diodes at the L/C junction. This scheme is used in many QRP rigs, including the previous versions of this rig. It was found that even when using two diodes in series, enough voltage could be produced at the high impedance L/C junction by strong SWBC stations to cause the diodes to conduct. This would then cause IMD.

To further improve performance in the presence of strong SWBC signals, double tuned input circuits are used on the 40 and 30 meter bands. These are not needed on 80 or 20, so only a single tuned input is used on these bands.

The first mixer input is connected to the tuned circuit, so it provides us with some passive gain. The input signal is then mixed with the LO frequency in U1 to provide an IF of 4.9152 MHz. The IF is filtered by four crystals. The filter is terminated by a 470 ohm resistor, which helps flatten out the filter response. Without the terminating resistor, the filter has peaks in the response.

The use of four crystals provides significantly better performance than the three crystals many other QRP rigs use. Four crystals provide somewhat more selectivity, but more importantly, they provide much better rejection of the opposite side band. You will be much less likely to be tricked into trying to contact a strong station on the wrong side band with the four crystal filter than with a three crystal filter.

The IF is then mixed in U2 with the BFO oscillator to produce the audio base band signal. 1000 pF caps from the output pins to ground helps eliminate RF mixer products and reduce high frequency hiss.

The output of the BFO mixer drives a differential input op amp. Using differential instead of single ended input effectively doubles the output of the mixer for a 6 dB voltage gain. It also eliminates any common mode signals which might be on the output of the mixer. This first stage provide a voltage gain of 33. A dual diode is connected across the amplifier feedback resistor to clamp strong signals. These diodes keep the following AGC amp from being overdriven, which causes distortion and charges the AGC hang cap to the point it takes a few seconds to recover.

The output of the first audio stage then goes into a Panasonic audio AGC amplifier, which provides an additional 26 dB of audio gain, before AGC action starts. This part was meant to be used as a microphone preamp and AGC in cell phones, but it works well here to eliminate the need for a volume control, which we have no room for.

The output of the AGC chip then goes into a SPDT analog switch. This switch is used to mute the receiver by disconnecting the preceding audio stages and connecting the side tone to the audio output stage.

Finally, the audio goes into the head phone driver stage, with up to 105 mw of output drive, which is also configured as audio band pass filter, with a gain of 1 and 600 Hz center frequency. The Q is a modest 5 and this helps to peak the CW beat note. A 10 uH choke and .01 uf bypass cap keeps RF out of the audio amplifier. This was discovered to be a problem in earlier versions of the rig, when it was used in close proximity to an end feed antenna or one with open wire feed. The transmitted RF could cause the side tone to sound raspy.

Power for the audio amp chip is derived through a NPN transistor with the collector connected to the raw DC input and the base to the regulated 5 volts. This results in about 4.4 volts to the audio amp chip. The reason for doing this is because the 5 volt regulator can not supply enough current to the audio amp during strong signals with out losing regulation. Adding the transistor solves the problem and prevents audio oscillations.

Transmitter:

The transmitter is about as simple as you can get. The square wave output of the DDS is buffered by a pair of 74HC02 NOR gates, connected in parallel. Since the output from the DDS is high impedance when turned off, a pull up resistor is added to keep the output of the NOR gates low when not transmitting. Two gates are used in parallel as that lowers the output impedance and is better capable of driving the gate capacitance of the power output FETs.

The RF power amplifier is comprised of three 2N7000 trench FETs in parallel. The 2N7000's have a relatively high "on" resistance, so using three of them in parallel reduces their effective resistance and boosts

efficiency. They also share the load, enabling higher power output. PA efficiency is between 80 and 75%, depending on band. 80 meters has the best efficiency

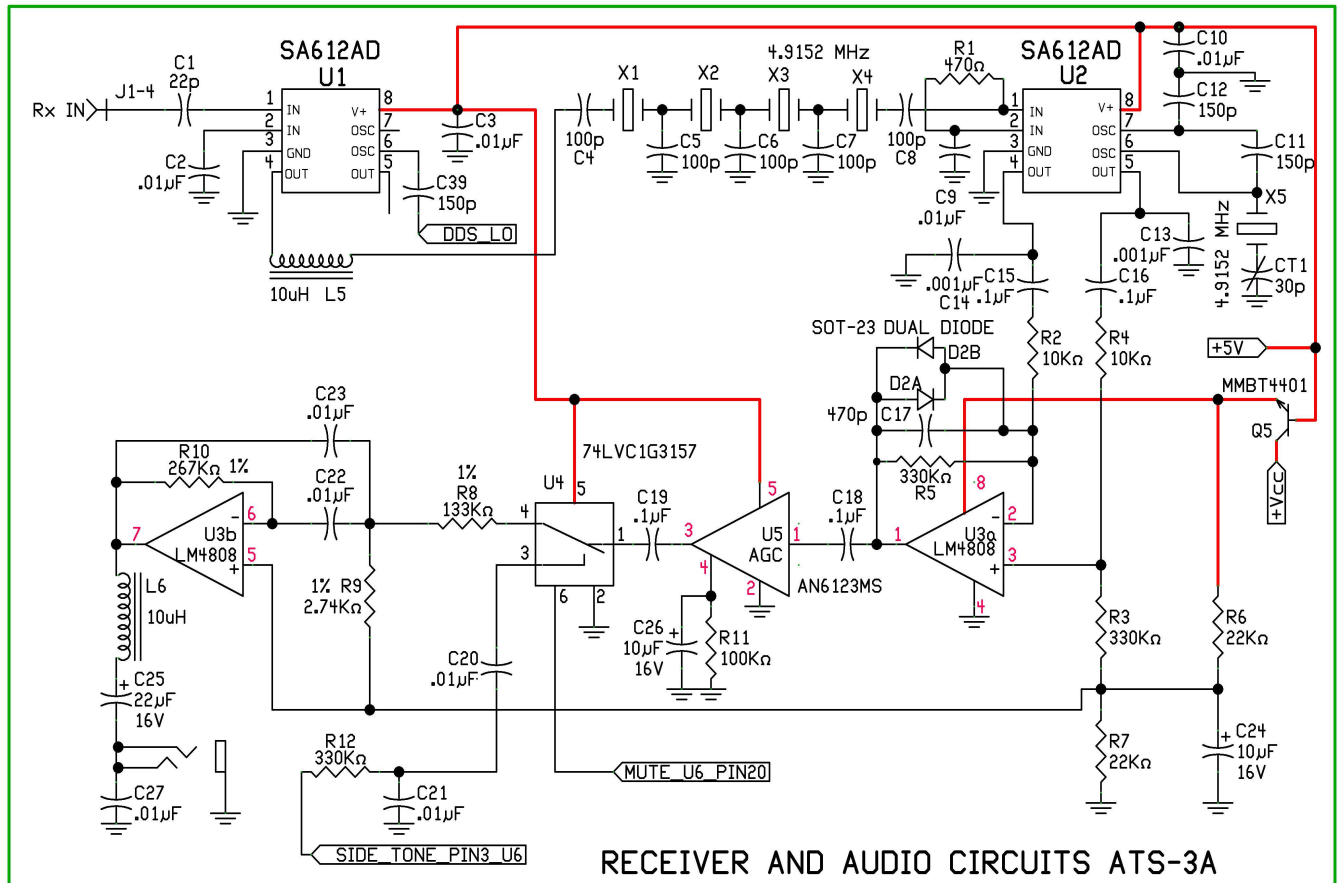
The drain to source break down voltage of the 2N7000 is a relatively low 60 volts. This can easily be exceeded when operating at 5 watts with a moderate SWR. Therefore, a 46 volt zener diode is added across the drain to clip the voltage. Even though a 1 watt diode is used, under conditions of very high SWR, the current can get high enough in the diode to cause it to short out. Therefore, very high SWR conditions should be avoided!

.A low pass filter connects the output of the PA to the antenna. This filter provides both impedance matching and harmonic suppression. The second coil in the filter is tuned to the second harmonic with a parallel cap. This greatly reduces the second harmonic and helps increase efficiency of the PA. An additional small inductor, 0.15 uHy is placed in series with the output of the LPF and the antenna terminal. This inductance, in combination with the connecting coax capacitance eliminates VHF spurs which can leak through the HF filter.

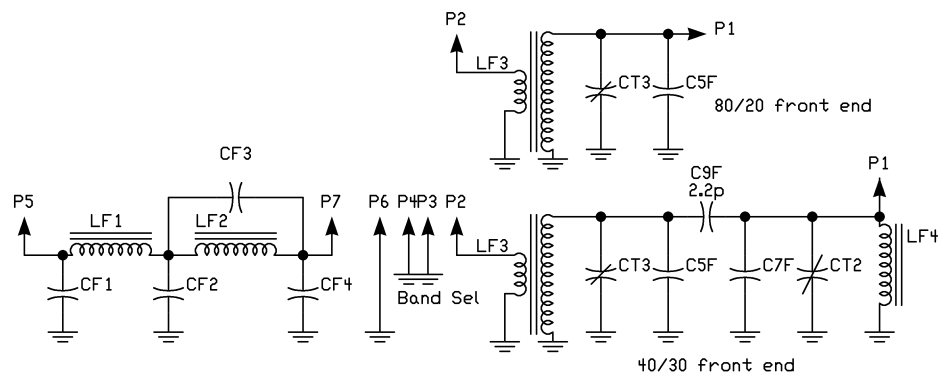
The PA is keyed by supplying power to the PA through a P Channel power MOSFET. This is done in order to produce some wave shaping of the keyed output signal. Resistors R13, R14 and capacitors C42,C43 form an RC time constant which provides for about a 5 ms rise and fall time of the output signal, as it is keyed.

Schematics:

Receiver section:



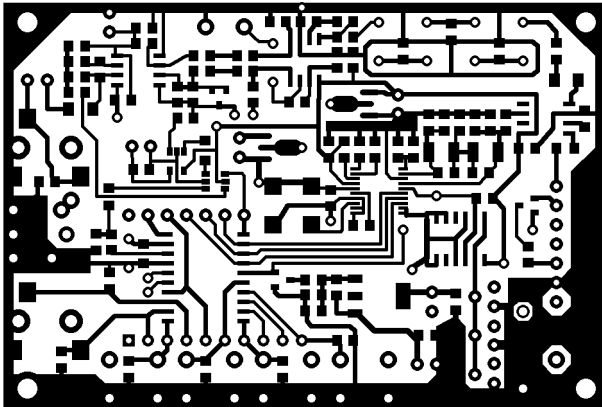
Filter board



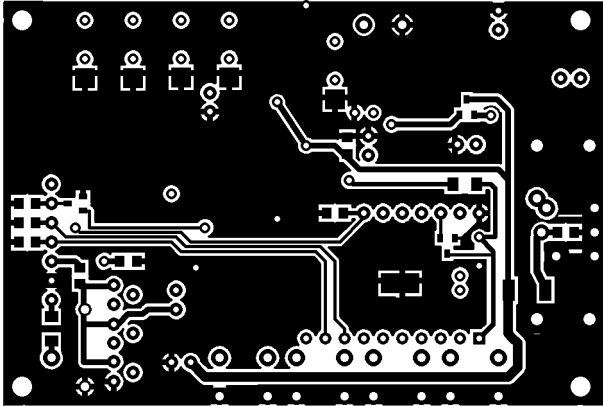
MPU/DDS/Transmitter (next page)

BOARD TRACK LAYOUTS:

TOP SIDE



BOTTOM SIDE:



Working with SMT parts:

If you have never worked with surface mounted parts before, it's not very difficult and can be an enjoyable experience. This section describes the tools and techniques you will need.

Tools:

At a minimum, you will need:

1. Tweezers
2. Magnifier (visor, lighted, hand held glass, etc.)
3. Hobby knife, such as Xacto™ with #11 blade
4. Small tipped soldering iron, (1/16" conical or chisel) 25-30 watts or temperature controlled.
5. Needle nose pliers, diagonal cutters, small screw driver.
6. Good light
7. Steady hands.
8. Optional SMT part hold down device.

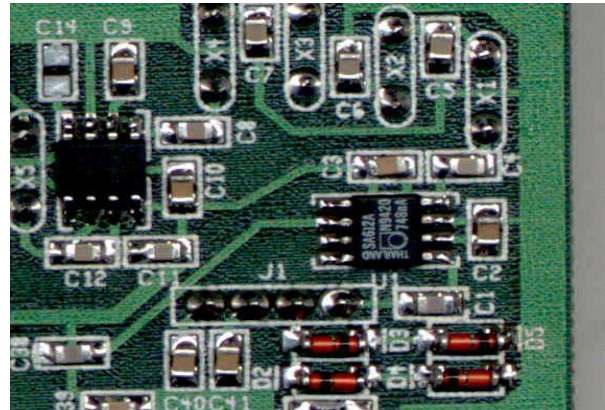
Instead of, or in addition to the tweezers, you can use a tooth pick with a dab of bee's wax on the end to make it sticky. With this, you can pick up the small parts and hold them down while you solder. A problem with tweezers can be if you grasp the part too tightly, it can spring out and go flying, never be seen again.

Removing the parts from the carrier

Many of the parts need to be removed from their carriers before use. A clear strip of plastic needs to be peeled off to expose the part for removal. To avoid losing a part, this is best done by holding the carrier in one hand, in front of you and against your work surface, then peel off the plastic cover using your tweezers. Once the plastic is peeled off, tip the carrier over to drop the part(s) out in front of you.

Soldering:

Some very thin (.010") solder is supplied with the kit for use with the SMT parts. (If you need more, Radio Shack sells this) Very little solder per connection is needed. Ideally, you want just a tiny concave fillet between the end of the part and the pad. The picture to the left shows examples of SMT soldering.



Chip caps, resistors and other two leaded parts.

1. Lightly tin **one** of the two pads.
2. Use the tip of your hobby knife or tweezers to peel back the clear cover on the parts carrier and then spill them out onto a clear work space above the board.
3. Pick up the part and place it over the pads. Try to keep it centered and squared over the pads.
4. Apply a little heat with the iron to tack the part to the tinned pad. A light wiping motion with the iron against the side of the part and the tinned pad should be enough to solder the part in place.
5. Solder the other end, be sure to heat both the end of the part and the pad at the same time.

6. If needed, return to the tacked end and apply a little fresh solder.
7. When placing a number of the same value part to the board, you can speed things up a bit by tinning the pads for several locations at once. Tack the parts down and go back and do the other end. Just be sure not to miss any!

Soldering IC's

1. Lightly tin one corner pad.
2. Place the IC and line up the pins over the pads. A little dab of Bee's wax under the chip can help hold it in place.
3. Tack down the corner pin to the tinned pad.
4. Verify the lead alignment on the pads. This is very important!
5. Proceed to solder the rest of the pins to the pads, usually starting at the opposite corner from the one you just tacked down. Ideally, you want a little solder to flow between the IC pin and pad. Therefore, don't hold the IC against the board very tightly, just enough pressure to keep it from moving as you tack the first pin.
6. Don't worry much about making solder shorts, especially with the fine lead spaced parts. See step #7.
7. Inspect the soldering with your magnifying glass. If there are any solder shorts, use solder wick to remove the bridge. Use the tip of the hobby knife to gently 'Nudge' the leads. If any of them move, you didn't get them to stick to the pad and need to be touched up.

Removing IC's

Should you ever need to remove a SMT IC, with out damage to the part or the board tracks, this is the way to do it. First, wick as much solder as possible from the leads. Now feed a piece of #32 magnet wire between the leads and the body of the IC. Secure one end of the wire to something on the board. Now grab the free end of the wire and as you heat the first pin on the IC, pull the wire out between the lead and the track. Keep doing this for each pin in line down the chip. Repeat for the other side. The IC will now pretty much just pop off the board. (But you might have to loosen up one or two of the end pins with a tad more heat)

Using Liquid Solder Flux:

Please don't! Its impossible to fully clean out from under parts and will cause leakage paths in high impedance areas, which can cause the circuits to misbehave and be erratic. The stuff is nothing but trouble so avoid it. Save it for plumbing jobs.